Growing Children

Thomas W. Nunn

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AND

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BY

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PREFACE AND INTRODUCTION.

AWKWARD walking may be something more than an ungainliness; ungainly gait may constitute an important symptom, requiring careful analysis; for the lower limbs have a complex relationship with other parts.

The various organs of the body are so interdependent, that defect at one point may injuriously react at a distance, and thus a slight imperfection of growth or of function may be the unsuspected cause of widely mischievous consequences. Abnormalities occurring after birth, acquired distortions, have a strong tendency to go from bad to worse, and on this account taken alone, any deviation, however slight, from the normal should not be disregarded, as that which at the outset might have been a small affair, in later years may become gradually and insidiously

the cause of a disabling lameness. Such imperfections are too often little heeded, their import being not understood.

Some knowledge of the structure and functions of the human body is especially valuable to those on whom has devolved the duty of watching the growth of the child, as it makes possible the recognition of early abnormalities, and puts the guardian on the alert as to the liability to trouble in the offing.

Popular lectures and ambulance classes have, it may be hoped, been useful in the direction of spreading instruction in these subjects; to the same end I have endeavoured to describe, in as simple a manner as I could, some elementary anatomical facts.

To those readers who will face a moderate amount of technicalities, I would mention, for study, Huxley's "Elementary Lessons in Physiology," Humphry's "Human Foot and Human Hand," Hensman's "Outlines," as giving accurate, clear, and artistic representations of the bones separately, and of the skeleton in relation to internal organs.

Bourgery's splendid volumes, "Anatomie Elementaire" and "Traité Complet de l'Anatomie de l'Homme," with plates by Jacob, to be found in

the library of the British Museum (Press marks respectively, Tab. 1800a and Catalogue desk M), afford, as far as it is possible for drawings to do so, demonstration of the collective organs of locomotion.

In the Natural History Department of the British Museum at South Kensington, is arranged by the Director, Sir W. H. Flower, a most instructive series of specimens illustrating the bony anatomy of man, and opportunity is given of comparing his skeleton with that of other vertebrate animals, or animals that have arrived at the dignity of a backbone.

The "Guide" to the Galleries of Mammalia, in which these specimens are to be found, will materially aid and enlighten the student.

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PART I.

GROWTH.

The progressive changes that take place during the development of the helpless new-born infant into the mature, strong, vigorous being, are at some stages gradual, at others rapid; some developmental processes are completed in twenty-four months, others occupy a period of as many years.

The different parts of the body do not grow on exactly parallel lines, even under perfectly normal circumstances. Thus, immediately after birth,[1] the height of the head is less than a fourth of the whole body, and the legs are longer than the arms, the upper arm being longer than the

[1] *Vide* Huxley's "Anatomy of Vertebrated Animals."

fore arm, and the thigh than the leg. At full growth the height is between three and four times the height of the new born child, and the arms are increased in length in a similar degree, but the head is only twice as large, while the legs are five times as long as those of the child. The female head at full growth is larger in proportion to the stature, but the chest is shorter and the abdomen longer than in the male, and the shoulders are narrower, the hips broader, and the thigh bone more oblique.

Mr. Roberts[1] says: "It has been already observed that the lower extremities develop more rapidly and in greater relative proportions than other parts of the body. Thus, from birth to maturity, while the head and neck double their height, and the trunk increases to three times its original proportions, the lower extremities in the adult are five times the length they were in the new born infant. The upper extremities grow less rapidly, the arms of the adult man being only four times the length they were at birth. Measuring from the fork to the sole of the foot, the lower limbs double their length before the

[1] "Anthropometry," by Charles Roberts, F.R.C.S., &c., &c.

third year; at twelve years they are four times, and at twenty-five years five times their original length. The thigh, the leg, and the foot do not increase in the same proportions. . . . The thigh grows more than the leg, and the leg than the foot."

The increase in stature and the special expansion of the frame follow no invariable and rigid prescript, but are influenced by factors of diversity.

The regular and orderly growth of the body is liable, from obscure causes, to interruption and disturbance from the very earliest date of its existence. The two side halves of the body are seldom symmetrically developed; as, for instance, the two sides of the face. The development of each of a pair of limbs is frequently unequal. In the case of the upper limbs it is a matter of common observation—in fact, it could hardly escape notice—that one hand is often larger than its fellow, and so this irregularity is looked upon almost as regular. Inequality of growth of the lower limbs, especially in length, although it is less apparent or conspicuous, is by no means rare and can be easily detected. On the equality in length of the lower limbs much depends, for the

balance of the rest of the body is interfered with by inequality.

The organization of the human frame is such that it gives the power of steady movement by means of the lower limbs, and of maintaining an erect and firm attitude upon the feet, and this power constitutes a special endowment. Man is distinguished from other animals in that he enjoys a monopoly of walking and standing by the use solely of the lower limbs. The assistance of the upper limbs in locomotion, unless under emergencies such as, for example, in climbing or in swimming, is not needed.

But as man is also distinguished by a larger brain and wider capacities, there is imperiously demanded the unimpeded and disembarrassed service of the upper limbs. And in respect of this point Sir Richard Owen thus described the characteristics of man: "With the predominant thinking organ has been given an instrument to do its bidding, to wit, a hand, liberated from all share in station and locomotion."[1]

"Man's skeleton," says Dr. Albert Gunther,[2]

[1] Introduction to Carter's "Zoology."

[2] "Guide to the Galleries of Mammalia," Zoological Department of the British Museum.

"differs from the Mammalian type, mainly in relation to the upright position of the body, and the total withdrawal of the anterior" (upper) "limbs from the function of progression, and their modification into grasping and tactile organs; at the same time the hind" (lower) "limbs are developed sufficiently to be capable, by themselves, of supporting and moving the whole weight of the body."

This capacity for movement of the body from place to place—locomotion—and for posture in the specially human attitude—station—by the lower limbs depends on the integrity of many and diversified organs: the nervous system, which conditions and underlies every function of the body; the muscles, the bones and their connecting links, fibre and gristle (cartilage), the joints, the state of the adjusted tenements for the great nerve centres afforded by the skull and spine; and on all these being kept in perfect going order by the constant activity of the apparatus for nutrition, and for the circulation of the blood.

The lower limb is, at command, at once either a rigid column or a series of moveable parts or segments acting as levers.

Station, or the erect posture, necessitates the combined and simultaneous contraction of groups of muscles, which, acting in opposite directions, hold firm the joints, as the shrouds steady the mast of a ship; for the body cannot be simply balanced on the legs, there must be continuous muscular force to hold the body upright. Locomotion, on the other hand, requires the alternating action of these groups of muscles, and by virtue of the joints, the bones of the thigh, leg, and of the foot taken together, are converted into so many levers. But these bones differ much in character; some are long bones, some short bones. The bones of the skeleton generally, have been classified by the anatomist as long, short, flat, or tabular, and of a mixed character. Long bones are described as having a shaft which is either cylindrical or prismatic, and as being equipped with expanded ends, which enter into the construction of the joints, and as having certain projections which give favourable points for muscles to be attached to, or to take hold. Bones of the short class have no shaft, but consist of masses of bony substance; they have smooth surfaces where they come in contact with other bones at joints, and they have rough grooves,

and rough surfaces also, to which are affixed the fibrous material which binds them to other bones independently of joints, or where muscles are attached. Bones have a membrane covering them, which is intimately and closely adherent; this membrane has an essential share in the nutrition of bones.

The expanded and moulded ends of the long bones, as well as the smooth facets of the short bones, are encrusted with gristle or cartilage. This is in the form of a thin layer of a grey elastic, glistening material, of about the consistence of the kernel of a filbert; it has somewhat the appearance of mother-of-pearl. Cartilage, as this material is called, forms elsewhere a very essential constituent of the framework of the body, and when intermingled with fibre it enters into the mechanism of some of the joints, a combination of fibre and cartilage giving elasticity with tenacity. Cartilage is further a tissue of great dignity, for in the early stages of development it affords the matrix for the production of bone.

The cartilage covered ends of the long bones are either convex or more or less concave, and form the joints by the convexity of one bone being

received within the concavity of another; the bones are thus held in their places; in some joints the concavity is deepened by a rim of fibro-cartilage. The adaptation is secured by ligaments made up of a fibrous tissue, which has the appearance of white floss silk. The ligaments are seen as flat bands, or as bundles or cords, or as expanded into a broad sheet; some are on each side of a joint, some within the joint, some very strong ligaments are found in the foot and elsewhere between bones, and ligaments not only hold the bones in apposition, but limit the movement of a joint. The ligamentous fibres are intimately connected with bone, and with the enveloping membrane of the bone, just spoken of, which shares in the nutrition and development of bone tissue. This kind of tissue is also found in a membranous form around some of the joints, and encloses them, but in such situations, being lax, confers but little strength; however, it sustains a delicate membrane (the synovial membrane), yielding or secreting a viscid fluid (synovial fluid), a lubricant for the surfaces of the ends of the bones. This is indispensable for the prevention of friction. A very simple experiment will illustrate how friction is prevented by a

lubricant. Rub the hands together vigorously for a few seconds—heat is at once felt; repeat the rubbing after having greased, or better, soaped the hands—no heat will be generated, at any rate not until muscular action has caused more blood to be sent to the hands. One may say *en passant* that rubbing the hands to warm them is a very interesting physiological experiment; there are at least three points to be noticed in it: 1st, the friction mechanically produces heat; 2nd, this heat stimulates the nerves; 3rd, the nerves react on the blood vessels (these are called vaso-motor nerves), and cause a fuller supply of blood to be given to the part. Further, let it be observed, if the fingers be blanched and benumbed by cold, it will take long to bring about warmth, as the sensitiveness of the nerves is annulled, and the nerves can say nothing to the blood vessels commanding them to supply blood in greater abundance, and thus there is no help from the blood to add to the warmth.

In the development and growth of the skeleton cartilage plays a supreme *rôle.* The bones begin, devoid of mineral matter, as cartilaginous models of what is to be. Bone, at first soft, of a flexible

and plastic character, in due course, by having appropriated from the blood a large percentage of mineral material, becomes firm, solid, and elastic, as a billiard ball is elastic.

The conversion is effected by the deposit of mineral material (chiefly made up of lime compounds) in the soft cartilaginous rudiment of the bone. This process commences at certain points called centres of ossification, and spreads from thence. In the long run this deposit of mineral matter entirely alters the relative proportions of the mineral and animal matter from what obtained in the early months or years. The mineral matter in the adult bone is to the animal matter as two to one, but this proportion varies in some degree according to age, etc.

Albeit hard bone is not formed by the cartilage being simply driven out of the field by the mineral constituent, the metamorphosis is of a complex nature; it is as a usurpation modified by a subsequent constitutional government.

Different bones have not the same number of centres of ossification; and the moulded ends of the long bones, called the articular extremities, the ends entering into the formation of the joints, have in some instances more than one—the lower

end of the arm bone, for example ; and have, as it were, an independent existence, if one may so describe the organization which has a most important share in determining the growth and shape of the bone. The increase in the length of a bone takes place by the special activity of a stratum of cartilage which intervenes at the junction of the shaft or columnar part of the bone with the broadened moulded articular end. The special activity of this layer of cartilage is of the greatest moment ; it is a critical process, building up bone as bees build up additional honeycomb.

One has, therefore, to regard the expanded ends of long bones during growth as, to a certain degree, separate from the long cylindrical or the prismatic shaft, as portions federated only, so to speak, for the early epochs of life, but ultimately becoming, when maturity has been reached, firmly welded to the shaft.[1] The

[1] The complete solidification of the bones of the lower limb, that is, the complete union of the portions that enter into the formation of the joints and of some of the outgrowths or projections for the attachment of muscles, occupies an era extending from the seventeenth to the twenty-fourth year; the solidification of the thigh bone appears to precede that of the bones of the leg. This is a matter to be well borne in mind.

immense importance of the integrity of this intervening layer of *productive* cartilage is shown by the fact that when any disturbance of its own nutrition occurs, such as might arise from inflammation or from mechanical injury, mischief of a permanent character follows—the bone becomes deformed or misshapen; for, suppose that the cylindrical part of a bone shall lengthen, or grow less on one side than the other, it is obvious that a morbid curve must declare itself, and thus spoil the bone as a perfect instrument for leverage. In a parallel manner, if the separate bones that form the spine do not grow symmetrically, the spine, instead of being straight as an arrow in the fore and aft plane, acquires a lateral curve. Professor Sir G. M. Humphry[1] has illustrated this point in a paper on the thigh bone, and he has at the same time, by his extended observations, shown that some generally accepted statements regarding the details of the anatomy of this bone have been allowed to pass current, without challenge, by writers who committed themselves to statements without verifying the accuracy of the data upon which those statements were founded.

[1] "Journal of Anatomy and Physiology," April, 1889.

The stability of bone is maintained by the continuous clearing away of old bony matter and a corresponding replacing supply of new material. It has been found by feeding a growing animal intermittently with a food that is capable of staining bone red, that alternate strata of red stained and unstained bone have been formed. This circumstance permits the hope that a remedy for the results of antecedent faulty and defective nutrition may be discovered in therapeutic measures.

We have, then, as the basis of the limb, bone, and its immediate and nutrient covering membrane, cartilage, permanent and transitional, ligament, and lubricating membrane, the membrane that secretes the synovial fluid. The bones of the lower limb differ in character in a remarkable degree, thus the thigh bone is a long bone with a cylindrical shaft, and the two bones of the leg are long bones more or less prismatic. The kneecap (the patella) is obviously a short bone, as are the bones of the hinder part of the foot, while the bones of the front part belong to the class of long bones: they are three-sided, and have rounded heads; they act as outriggers to the toes. The bones in question are those which have a

position in the foot between the short, strong, massive bones of the instep and the toes, and are of the same nature as those bones of the hand lying between the wrist and the fingers. The bones of the toes belong to the shafted class.

The bones present, for the attachment of muscles, surfaces, and ridges, projections more or less pointed or otherwise shapen, all of which have a bearing on the direction of the muscular force acting on the bones as levers, and have relation to the joints.

The joints of the lower limb present certain marked features, especially in respect of their strength. The hip joint is a ball and socket joint, with a strong cord-like ligament directly connecting the semi-spherical head of the thigh bone to the centre of the socket, and it is to be noted that the smooth surface of the semi-spherical head of the thigh bone fits so accurately to the hollow of the socket, that atmospheric pressure helps to keep the bones together, just as the plate for artificial teeth is held against the palate by suction, as it is called. The atmospheric pressure, in a minor degree, shares elsewhere in maintaining the bones of a joint in proper position.

The knee joint presents an enormous amount of surface, and has been described as comprising

three joints in one. It has within it two crescent-shaped fibro-cartilages, and has the striking peculiarity of being completed by a short bone—the knee-cap or patella :[1] it is a hinge joint.

The ankle is also a hinge joint; and it has the protection on each side of prolongations respectively of the two bones of the leg.

The joints between the bones of the heel and instep for the most part consist of facets in apposition, while again the joints of the toes are hinge joints.

The movements permitted by the joints vary much in degree. The ball and socket joint of the hip allows of movement in every direction. The hinge joint of the knee is almost restricted to backward movements, that imply movements to restore the straight line of the limb, or, forward movement after the backward, (extension after flexion); lateral movements are possible only in the position of extreme flexion. The ankle joint allows of more latitude in the extended position of the foot—that is, when the toes are pointed downwards and are not on the ground. The bones of the instep are so tied together as to allow only a very limited movement upon each

[1] There are small bones at the under aspect of the great toe joints of an analogous character.

other; at the same time, small as such movements are between individual bones, the sum of the movements is an indispensable amount in the working of the mechanism of the foot, as it allows the impact of the weight of the body to be diffused or spread, and to be thus supportable. The joints of the toes provide a hinge movement and lateral movements to a small extent.

The long bones of the limb and the combined short bone of the foot constitute so many levers acted on in locomotion by the alternating force of the various groups of muscles. A lever is a rigid bar, or rod, by which a given power is so transmitted as either to confer rapidity of movement of a thing to be moved at the expense of force, or, by a loss of rapidity of movement, to gain force.

A lever requires for its completion a fulcrum or pivot, on which the lever, the rod or bar, can move. Different kinds of levers are described; they differ as regards the relative position of the thing to be moved, the fulcrum, and the power; the same mechanical arrangement may be, under varying circumstances, two kinds of levers. For instance, the common hand-barrow used at railway stations for lug-

gage; the porter lifts a heavy package by thrusting the iron shovel end of the barrow under it; the fulcrum is the axle of the barrow, and lies thus between the weight to be moved and the power—namely, the man at the end of the long handles of the barrow; thus the weight is on one side of the fulcrum and the power on the other; directly the porter has lifted the package, and the handles of the barrow have been brought from the nearly vertical position in which they were at the beginning of the task to a more or less horizontal one, the package or weight will lie on the same side of the fulcrum as the power; instead, then, of the fulcrum being between the power and weight, the weight is between the power and the fulcrum. Then, again, the power may be between the fulcrum and the weight; at the elbow the muscles of the front of the upper arm are fixed into the bones of the fore arm, just below the elbow joint, which is the fulcrum; the muscles are the power, and the hand is the weight to be moved; a small shortening of these arm muscles produces a great movement of the hand, but it is to be recollected, however, at a large expenditure of muscular energy. The leverage here is like that of an old-fashioned

door-latch fixed at one end on a pivot, the opposite end being heavy to catch into a notch on the door-post, while there is a knob projecting, between the catch and the pivot, by which the heavy end is lifted from the notch. .Here is an example of a lever precisely on the principle of that provided by the fore arm, as just stated : the pivot or fulcrum is the elbow joint, the heavy end is the hand and what it may hold, and the lifting power are the muscles in front of the upper arm, the name of one of which is familiar, the biceps. This muscle and an associated muscle take hold of, or are attached, or fixed, to the bones of the fore arm near the joint—an arrangement that endows the arm with great rapidity of action.

The joints have no automatic power of movement, but are moved by muscles. Pictures of walking skeletons are evolved only from the imagination of the unphysiological artist.

The endowment of a muscle is its capacity or property of exchanging its length for breadth : it shortens, and becomes in consequence broader or thicker ; therefore, if fixed at one end to a point that, for the time, cannot move, and at the other end to a point that can move, it draws the movable point towards the fixed point.

To say that a muscle contracts is only to half state the case, for when a muscle contracts in one direction it expands in another; its length diminishes, but its breadth increases; its actual bulk remains the same.

A muscle, speaking generally, as an organ of movement, is completed by its tendon. A tendon is as much characterized by its inextensibility as a muscle is by the opposite property: the muscle is very freely supplied with blood vessels and nerves; the tendon is sparsely so supplied.

The tendon, or sinew, carries the power of the muscle as the tiller ropes carry the power of the man that steers; it is somewhat, but slightly, elastic, and in many situations it transmits the force as a cord would over a pulley, altering the direction of the force.

The tendon, while it represents all the power of the muscle, occupies far less space; for instance, at the wrist, where the tendons belonging to the muscles of the fore arm are aggregated, the circumference will be found little more than half of the measurement of the largest circumference of the muscular part just below the elbow. The tendons, too, serve to concentrate the force of the muscles on points of the bone which the muscle

has to move. In structure, tendon and ligaments —the fibrous cords which hold the bones in apposition—are of very much the same material. Between the fibre of muscle and the fibre of tendon there is a great contrast; the former is red, the latter brilliant, shining white; the one instinct with movement, the other passive.

The tendons run in sheaths, also lubricated by the viscid transparent synovial fluid. These sheaths are at some points strengthened by transverse bands of fibre, which keep the tendons in their places and determine the direction of the force of the muscles.

Absolutely unimpeded liberty of movement of the tendons is essential for the full play of the muscles, and this the synovial fluid lubricating the tendons insures. The rapidity of such movements may be imagined when the fingers can perform over 1000 movements in a minute; as, for example, rendering a passage of music on the pianoforte.

Chevalier Ganz was so good as to make an experiment for me to show how many notes could be struck in the minute; the result went to prove that he could, without very great effort, strike 252 in fifteen seconds, or 1008 per minute.

This by no means measured the whole of the muscular movements, as each finger would require to be lifted and then brought down on the key of the piano, and shifted laterally as well. It may be added that the rapidity with which the sound of one note succeeded another was so great that the sonorous effect produced resembled the moan of an approaching cyclone.

While muscles end in the tendons, and some muscles start from tendons or tendinous tissue, certain muscles begin, springing as it were, from an extensive surface of bone or of membrane. Some of the conditions of the attachment of the muscles confer protection against injury from sudden strain: a sudden strain will fracture, where a steadily and gradually applied force would do no harm. In the fishing rod, the delicately tapering, highly elastic rod prevents the jerk of a heavy fish snapping the line, the strain on the line being made gentle by the whole length of the rod sharing in it.

We see this protection against sudden strain in the investment of the limbs by a fibrous membrane which dips in between the muscles and becomes fixed to the bone; and to this investing structure some of the muscles of the limbs

are partly attached or connected. For example, the great muscle of the buttock is not only firmly fixed to the upper part of the shaft of the thigh bone towards its hinder surface, but is fixed as well to fibrous investment of the thigh, and thus lays hold of the outer side of the knee and upper end of the bones of the leg; in this way the power of the muscle, which is one that largely helps to sustain the body on its legs in the erect position, is spread over an extended area, and the strain is divided between a limited surface of the thigh bone and broad expanse of a very strong, tough sheet of fibrous membrane having manifold points of attachment to bone. It may be mentioned in illustration that the tendon of the biceps alluded to at page 18 as concentrated in its attachment to one of the bones of the fore arm, gives a fan-shaped offshoot to a membrane which envelopes the muscles of the arm.

The other investing tissues of the limb, the skin and the immediately subjacent fibrous membrane, are flexible and elastic; the necessity for this elasticity is prominently shown at the knee joint. In bending the knee backwards to an acute angle with the thigh, the distance of

the top of the leg bone from the lower end of the front of the thigh bone is increased by about two or two and a half inches; so, if the skin were incapable of stretching, it would split or crack were that movement carried out.

At some parts an abundance of fatty tissue is essential; as, for instance, between the bone of the heel and the skin of the heel, where it forms a cushion, and softens the concussion when the heel comes sharply to the ground.

Another situation where there is more or less fat is at the back of the knee joint. The purpose is not so obvious as at the heel. The fat probably serves to protect the great vessels and nerves lying in that region.

Now, some especial reference to the anatomy of the skull and spine, and their contents, brain and spinal cord, and their functions, is necessary.

THE BRAIN AND SPINAL CORD. THE SKULL AND THE SPINE.

The nervous system consists of two batches of nerves and nerve centres; immeasurably the largest and most potential one is made up of the brain and spinal cord, and is contained within the skull (the cranium) and the backbone (the vertebral

column). The smaller one, called the sympathetic system, lies outside these bony envelopes, and in its functions and structure differs more or less from the brain and spinal cord. In fact, the precise duties of the "sympathetic" are not known; the intermingling of fibres from the greater nerve centres makes the difficulty in arriving at the independent share the sympathetic nerves have in the general innervation of the body.

Both of these great centres first named are continuous the one with the other, and consist of nerve force producing centres and nerve force and impression conducting fibres, and from them proceed other fibres, called nerves, to every part of the body. One might in a rough way compare these elements respectively to the cells of a galvanic battery and the wires that conduct the galvanic current. Although the spinal cord is the channel by which the brain is mainly in touch with the body and limbs, it is more than a mere conductor, in virtue of its nerve force producing capacity, as just stated. The brain and spinal cord are also impression receiving centres; nerves passing from the outside to these centres conduct impressions. When you grasp a friend's hand,

you do so by the nerve force at your will, the nerve force of the brain being transmitted to the muscles which close the hand by nerves passing *through* the spinal cord; when you are conscious of feeling the responsive pressure of the friend's hand, the brain has recognized the impression and has converted it into a sensation. But the receiving centres can take cognizance of an impression without ordinary sensation being produced, and can straightway cause to be evolved a corresponding activity at a distance, an echo-like nerve phenomenon of an impression in which consciousness does not necessarily participate: such an echo is called a reflex nervous action. One may liken the reflex nervous action (which is not, however, quite a simple echo) to the movements that take place when, say, two children, A and B, are playing at ball. Suppose A to throw a white ball to B, and after catching it B throws back a ball which is red; thus something that A does causes B to do very much the same, but the ball is of a different colour; so an impression on the nerves (called nerves of sensation) of the surface is carried to a nerve centre, brain or spinal cord, by the nerve centre in response to the impression, a mandate is sent forth, and a reflex muscular action takes place.

Reflex processes have high duties to perform. They are the night and day guardians of the system, ever active, and they maintain and keep active the vital functions under opposite conditions, as of sleep and wakefulness. There are some actions allied to reflex actions called automatic. Breathing is a reflex action ; holding the head up under ordinary circumstances, for example, is an automatic action. Thus, when a person falls asleep sitting in a chair, the head drops forward, being no longer automatically sustained by the muscles at the back of the neck ; but breathing continues without interruption.

The nerve tissue, pure and simple, the medium of these phenomena, whether it be nerve-force producing or the nerve force conducting element, is of the utmost delicacy, subtle structure, and fragile consistence. The great mass of nerve substance within the skull, the brain, has for its protection, thus so essential, intervening layers of strong fibrous membrane which support the several lobes or divisions of the brain, and it has as well a general envelope of the same sort of tissue. The spinal cord within the spinal canal is provided with a fibrous sheath, and the nerve trunks emanating from the cord are fortified by admix-

ture with fibre identical with the envelopes of the brain and spinal cord. There are other protective structures, those for the brain differing somewhat from those of the spinal cord, such differences being in harmony with the rigid solidity of the skull and the flexibility of the spine.

There is this important distinction between the skull, the bone case for the brain, and the spine, the bone case for the spinal cord; namely, the skull, we may for our present purpose say, is built of tabular or "flat" bones immovably dovetailed together; on the other hand, the spine, or vertebral column, is built of separate bones of the mixed character, all of which have some movement upon one another; and it is this mobility of the separate vertebræ which confers the flexibility to the vertebral column, and which we have here to take into account; leaving aside the construction of the skull, and its relation to ideal or typical vertebræ. There are twenty-four vertebræ to make up the moveable vertebral column: with the exception of the first or topmost bone, which is next the skull and is so placed on the vertebra immediately beneath it, that wide movements of the skull upon the spine are possible, all the other bones (vertebræ) have parts more or less

resembling each other. These bones, tied and linked together, but in such a manner as to permit movement, constitute the vertebral column, the back bone, solid in front and hollow behind; for each bone (vertebra) is made up of a segment of a pillar or cylinder and a segment of a tube.[1] Interposed between the separate vertebræ are cushions of a highly elastic substance, which, while they constitute a connecting medium, form the elastic element of the spine, and, assisted by other more fibrous structures, bind one bone to the next. The spine, therefore, presents alternately a bone and a pad of elastic fibro-cartilage, and has besides a peculiar elastic ligamentous tissue, which fills the interval between the segments of the tubular part of each vertebra and adds to its completeness. Thus we have both a solid flexible column and a tube, and this double nature of the spine must not be lost sight of. The vertebræ, being bones of the class intermediate between long bones and short bones, present from the exterior aspect of the tubular portions projections, some of which reach directly backwards and are very evident, making a familiar feature in the lower

[1] The second vertebra has a pivot upon which the first vertebra turns.

part of the neck and upper part of the back just above the shoulder blades; others have a lateral direction, but, instead of being prominent, are concealed by overlying muscles; these afford short handles, like the outside spokes of the steering wheel of a ship, for muscles which assist in moving the column, and they otherwise share in the structure of the frame; one of their purposes is to help to steady the ribs.

The spine, limiting the name to the two dozen separate vertebræ, is perched upon a solid mass of bone (the sacrum) placed between the two haunch bones. The shape of this mass is that of a much flattened cone, and is distinctly and characteristically curved; the base of the cone is uppermost; in an early stage of development it existed as five and sometimes six pieces resembling vertebræ. There are some extremely strong short ligamentous cords and a layer of fibro-cartilage holding the haunch bones to it. The sacrum has at its lower extremity a few small bones of not much importance, which form a rudimentary tail.

On each side of the tubular division of the spinal column are a series of openings, formed by the juxtaposition of notches in two contiguous vertebræ,

in that part of the vertebra that has its share in the formation of the tube. These apertures are for the exit of the nerves springing from the spinal cord and for their associated blood vessels. There are corresponding apertures in the sacrum, but such are found in front and at the back, instead of at each side.

For the support and movement of the spine is a complicated series of muscles. The principal mass of these is fixed below to the haunch bones and sacrum, and extends itself upwards to the ribs and to projections of the back bone; an infinite number of smaller muscles lie between one vertebra and another, and aid the chief muscles, which are those of the loins, in the multifarious movements of the spine.

The spine, or vertebral column, at birth is nearly straight, at maturity has an inclination, or curve, forwards in the neck, backwards between the shoulder blades and as low as the waist, and then again forwards in the loins. Inclination to the right or left, described by some anatomists as normal, does not exist except as an abnormality dependent either on a fault primarily of the spine or on disparity of the lower limbs; this was shown by Mr. William Adams.

The advent and manifestation of the fore and aft curves belong to a phase of development and are analogous to the eruption of the second set of teeth. I would lay especial stress on the view that the nature of these curves is essentially developmental. Further, the forward curve of the spine in the loins permits of the chest being held in the most advantageous position; if the lower border of the chest falls downwards, the upper ribs have not full play, the cavity of the chest is inefficiently expanded, particularly at its upper part. It is a vital question whether, under such circumstances, the deposit there of tubercle may not be favoured. The normal curve backward in the region of the chest affords more space for the accommodation of the lungs and heart. When the spine or this region is unduly vertical, shown by there being a hollow between the shoulders, the ribs are seen to be too convex in front, and the heart is crowded against the ribs.

Professor Sir W. Turner[1] has described and discussed the question of certain racial differences in the skeleton—the shape of the skull, the relative lengths of the fore arm and upper arm,

[1] "Journal of Anat. and Phys." vol. xxi., On variability in human structures, etc.

the shape of the haunch bones and the curves of the spine and sacrum (the cone-shaped representative of agglomerated vertebræ interposed between the haunch bones), and many other skeletal peculiarities.

The lesser degree of curve in the loin region of the spine in some races of men of the lower type is remarkable, and appears to be dependent on the shape of the vertebræ and also of the elastic pads between the vertebræ (called intervertebral discs). Sir W. Turner says, "Now, should the habits of any race or races be such as to occasion a greater weight or pressure to be transmitted through the spine to the pelvis" (the haunch bones combined with the sacrum) "than in other races, a modification in these regions would arise, which would be perpetuated from generation to generation."

There is a very important fact regarding the relative growth of the spinal column and that of the spinal cord therein contained. In very early life the spinal cord occupies the entire length of the spinal canal, or tubular part of the vertebral or spinal column—that is to say, the cord and the canal are of equal length at first; later on, the spinal cord is only two-thirds as long as the canal,

the growth of the spine has outstripped the growth of the cord; the result is that below the waist the spinal canal contains no actual cord, but the nerves only, in which the spinal cord terminates.

There are some differences between the spine of the male and female. The female spine is not so strong, and has more flexibility, such being permitted by the greater length of the segment of the body between the lower edge of the chest and the upper edge of the haunch bones. This mobility of the spine in the female, combined with its less solid construction, renders the girl's spine more liable to some want of order in the normal curves, and also to a tendency to lateral (abnormal) curvature, under certain conditions especially in the loins, the region of the waist.

But nevertheless there is a countervailing advantage in the pliancy of the waist, as a greater extent of reach for the hand is bestowed by it. The much-vexed question of the waist has not been generally argued in all its bearings, and it demands some remarks. Sir Richard Owen, in the words quoted at page 4, has described the relation of the hand to the body, and the call for its special endowment and independence. In the female, the pliancy

of the waist makes up for the shortness of the collar bone. We see, in woman, the collar bone is not only more delicate, but is shorter than in the male. As regards the skeleton, the collar bone holds the shoulder blade; in turn the shoulder blade holds the arm with the hand; so the length of the collar bone, leaving the length of the arm bones out of the estimate, expresses the distance the hand can reach; or, the longer the collar bone, the greater the reaching power. The flexibility of the loins or waist compensates the woman for the shortness of the collar bone, and thus in some measure the disadvantage at which she is placed, as regards the inherent capacity of reach, is neutralized by her being more easily able to bend the body to either side. In this way Nature, holding or sparing with the one hand, gives with the other.

Sir G. M. Humphry[1] said of the foot that its formation is "found to have a correspondence with the formation of the head, and may, like it, be, to a certain extent, taken to be an index of intellectual as well as physical capacity. The relation between intellectual power and physical conformation of man . . . which is maintained throughout the frame, is a

[1] "The Human Foot and the Human Hand."

subject of extreme interest, and is one which has not attracted the attention of anatomists and ethnologists so much as it deserves." To a certain extent, therefore, the conformation of the waist has a claim to be regarded as a part of the same subject, and the observations of Sir W. Turner regarding the racial peculiarities of the spine also, help to elucidate this point.

There are two or three stock wood engravings, which have been used over and over again to illustrate disquisitions on the waist, and on the iniquity of the corset, intended to show how the compression of the ribs, by tight lacing, causes the figure to vary in shape from the torso of the Venus de Medicis, the work said to be inspired by Praxiteles. At the risk of being thought, by some, heretical, I venture to doubt the anatomical accuracy of the celebrated marble. But concerning regulation-fine-art criticism and æsthetics I have nothing in this place to say, being limited to matters of fact.

PART II.

WALKING.

Walking.—*Locomotion* on the feet is effected, as already stated, by the successive and alternating activity of the different groups of muscles. This alternating muscular energy is in striking contrast with the continuous and combined action of all the groups in standing still, *station.*—In walking, joint movements take place at the hip, the knee, the ankle, and the toes. The thigh has to be lifted towards the trunk through the hip joint, the leg to be lifted towards the back of the thigh through the knee, the foot moved upwards and downwards through the ankle. In the two first instances, the bending of the limb has to be followed by straightening or flexion, by extension. The different groups of muscles, by their relation to the bones, the levers, can exert force in opposite directions: some bend the joints, others straighten them, while move-

ments of less simple character can be produced by combined action.

The muscles of the lower limbs may be considered for the time being of two classes—the lifting and propelling, and the sustaining and manœuvring. In the act of walking, when the foot moves the body, the lifting and propelling muscles take the chief part; when the body moves the foot, the sustaining and manœuvring come into play, to poise and adjust the foot.

The movements of the foot in walking are to be divided into those on the ground and those off the ground. In ordinary walking, the foot on the ground has a rolling motion from the heel to the tips of the toes, especially to the tip of the great toe. The foot comes to the ground first at the heel, and it is then gradually laid flat; the heel is afterwards lifted, and the rolling action commences.

Sir Wm. Flower thus describes the movement after the foot is on the ground: "The heel is first lifted from the ground, and the weight of the body gradually transferred through the middle to the anterior end of the foot, and the final push or impulse given with the great toe." [1] Pettigrew says: "The heel first reaches the ground and first

[1] "Fashion in Deformity."

leaves the ground; when the heel is elevated the weight of the body falls more and more on the centre of the foot and toes, the latter spreading out to seize the ground. The spreading action of the toes is seen to perfection in children."[1]

The movement of the foot off the ground—that is, while the body moves the foot—is a rocking one, on the ankle joint; the front of the foot is raised, whilst the foot is slung forward by the leg and is carried clear of the ground; the foot is then gently dropped, so that it may be laid flat; there is also a very slight outward turn, and by it contact with the opposite ankle is avoided; the outward turn, it is to be remembered, comes from the hip joint. To follow with the eye the movements of the leg and foot is very difficult; a series of instantaneous photographs would be required to show them.

This description of walking applies only to walking in a direct line forwards, and on level ground; a modification of the movements occurs, for example, in climbing a flight of stairs or a steep path. We may here note that any other movements than such as carry the foot in the desired direction involve a waste of muscular

[1] "Animal Locomotion."

energy and the planting of the foot in a more or less disadvantageous position for the next step. It is often observable that each foot, during the swinging forward, performs movements that are all waste. The feet also may be seen not to move the one like the other; one foot may move fairly well, the other shifting about in useless gyrations.

Professional pedestrians find that to obtain the greatest pace the one foot must be placed in a line directly in front of the other, and it is said that soldiers trained to march with the foot turned outwards do not make successful competitive pedestrians. Mr. Ellis, of Gloucester, maintains, in his work on the human foot, that the toes should first touch the ground. Now, as the toes leave the ground last, it would follow that in progression, according to Mr. Ellis's view, the toes would be twice called on.

In stepping backwards, doubtless, the toe first touches the ground; but, in stepping forwards, the heel commences the rolling action of the foot.

There is a just perceptible rise and fall of the body in walking. The limbs during each step form an angle with each other, and consequently the body must slightly descend.[1] [The absence

[1] How this happens may be easily illustrated. Take

of this rise and fall in progression is striking if one observes a cycle-rider; his legs are seen in vigorous movement, but the head glides forwards without any oscillation, imparting to the rider an almost uncanny aspect.]

The trunk and upper part of the body also is swayed forwards and from side to side by a combination of muscular action, in which nearly all the muscles of the body take part; by this swaying the weight of the body is canted over to the leg just planted on the ground, and the lifting by the agency of the foot is thereby materially assisted.

Walking—locomotion—forwards may, however, be replaced by locomotion in other directions; for instance, backwards or sideways, and on intermediate lines. The arrangement of the groups of muscles provides for such indispensable modifications of locomotion.

For all these multifarious movements there

two volames of the same size; place them a few inches apart on their edges, so that the backs of the books are uppermost. A ruler laid across the backs will be level. Now half open one volume. The ruler will be no longer level, but will be inclined on the side of the opened volume, since the back of it will have descended, in consequence of the side covers being at an angle, instead of being parallel with each other.

are muscles reaching from the front of the spine, and from the front and back of the haunch bones, to the thigh bone at many points, and as well, but less extensively, to the two bones of the leg at their upper extremities; and there are besides muscles reaching from the thigh bone to the same parts of the leg bones. From the front and outer side of the leg pass muscles allotted to the instep and toes; from the back of quite the lower end of the thigh bone, and from the back of the leg bones together, muscles destined for the heel; from the leg bones muscles for the under aspect of the instep, great toe, and the four outer toes; and, lastly, a multitude of smaller muscles, on, under, and between the bones of the foot, which help to regulate the movements generally of the toes.

Some of the muscles are simple, and others are compound or double, while the muscular fibres making up the muscles run parallel, or they run at an angle with the tendon to which they are fixed.

The great muscle of the calf of the leg is a compound muscle: two muscular masses differently attached—one part above, to the lower end of the thigh bone; the other part to the two

bones of the leg, ending in the strong tendon (the Achilles tendon) which is below, fixed to the heel. An example of a simple muscle is the muscle going from the front of the leg to the great toe.

The functional result of the action of the groups of muscles depends in a great measure on the position of the limb with regard to the trunk; a propelling muscle may be, under certain conditions, a manœuvring muscle. To give a somewhat analogous instance in the upper extremity of interchangeable functional result: if the shoulder blade be held firmly by the muscles at the back, some of the muscles of the front are able to lift the ribs, and thus expand the chest. On the other hand, the muscles of the back remaining passive, those that would otherwise lift the rib draw the shoulder forwards.

It may be well to repeat and emphasize that the great variety of movements of which the lower limb is capable are made possible by special construction of the hip joint, a ball and socket joint, which permits of the limb being carried in every direction, and by the mechanical advantages conferred by the "neck," as it is called, of the thigh bone.

The knee joint, although so large a joint, can only move as a hinge, unless it be extremely bent (flexed). Almost the same may be said of the ankle joint, for when the foot is bent upwards the joint becomes locked and no lateral movement can be made; if, however, the foot be extended fully—i.e., be held so that the toes point towards the ground—some considerable degree of lateral movement is practicable. Beyond the ankle joint are the joints of the instep bones, allowing only a slight gliding. The joints where the toes are attached to the long bones of the foot, although hinge joints, have a certain amount of lateral play.

The joint of the great toe has a wider mobility, and is otherwise distinguished by having two small rounded masses of bone on its under surface, which enter into the formation of the joint somewhat in the same manner as the knee-cap enters into the construction of the knee joint. Diminutive representatives, however, of such small bones sometimes exist at corresponding joints of the other toes.

A few simple experiments will better show the action of the muscles of the lower limb than a written description.

1. Stand with the feet close together, then stand on tiptoe; in this latter movement, the muscles of the calf will be felt to lift the body vertically, the foot acting as a lever, the fulcrum being at the toes, the power at the heel, and the weight between the two; then, on placing one foot in advance, provided the calf muscles of the leg of the opposite side contract, a change in the direction of the force takes place, and the body is forced forward instead of being lifted; the vertical motion is exchanged for a more or less horizontal one.

2. Stand with the feet again close together, then turn one foot outwards. The motion will be perceived to come from the hip joint; the leg may be moved backwards and forwards from the knee without help from the hip muscles, but cannot be turned outwards.

3. Walk forwards on the heels only, keeping the knee straight; the muscles of the thigh will be felt to do all the work of progression; then instantly walk in the ordinary manner, and the lifting action of the calf muscles will be made very manifest.

4. Commence to ascend a flight of stairs. The first movement is a bending of the knee and lift-

ing of the one foot by the muscles of the thigh, so as to place it on the step. The next movement is a leverage by the other foot to lift the body, which is simultaneously swayed forward by the muscles of the trunk. Contrast this with endeavouring to ascend without the leverage of the foot—that is, by starting the second foot from the heel—and observe the extra strain on the muscles of the thigh required.

5. Scrutinize the action of the muscles in descending a flight of stairs. The sustaining power of the muscles of the thigh and the manœuvring of the foot by the muscles of the leg will be very observable.

6. Stand sidewise at the back of a chair, hold on by the top rail, then raise the foot from the ground; it will be perceived that the thigh is lifted towards the trunk and the knee is bent (flexed). Endeavour to lift the foot from the ground, keeping the hip joint and knee rigidly fixed; it will be found that in order to lift the foot the whole body must be bent over to the opposite side; in this way the haunch bone carrying the limb is tilted over, and the other haunch bone rolls on the top of the thigh bone at the hip joint.

In some cases, where the hip joint is quite fixed by old inflammation, the vertebræ of the loins become remarkably mobile, and a kind of substitute for the lost mobility of the hip joint is afforded by that acquired between the vertebræ of the region named. I have seen this where the subject of the disability in the hip had to earn his living at the lathe; he stood on the sound leg and worked the treadle of the lathe with the damaged limb by the acquired mobility of the loins.

7. In rising from the sitting position with the legs stretched out, observe that, first, the knees are bent, the feet being thereby drawn back; the body is then swayed forwards, so that the weight lies over and above the knees; at the same time the knees are straightened—thus the body rises. The straightening of the knees raises the body. In walking, the straightening of the knee, instead of lifting the body, propels it forwards, the vertical movement, as in experiment 1, being replaced by a horizontal one, the direction of the muscular force or energy being changed.

The propelling force of the muscles that straighten the knee is remarkably displayed in cycle-riding. The whole forward movement is

the result of this change in the state of the limb from *flexion* to *extension.* The flexed (bent) limb is seen to extend itself (straighten), and then immediately to be again flexed, and so on. The straightening plays the most important part, as the flexion is partly carried out by the movement of the crank actuated by the extending leg on the other side of the wheel.

PART III.

AWKWARD WALKING AND SPECIAL DEFECTS.

The movement of the foot in walking is a harmony, but one very liable to be converted into a discord. Injuries in early childhood, unobserved or unrecognized, from falls or sprains, frequently lie at the root of ungainly walking. We must, however, look more in detail for what it is that hinders the muscles from moving the foot in the manner most conducive to obtaining the best result. Is the fault in the muscles themselves? Are they insufficiently stimulated by the nerves, under-nourished by the blood vessels, or are they placed at a disadvantage by reason of an abnormality in the shape of the bones, and in the conformation and internal economy of the joints? Is there some disturbed condition of the nervous system by reflex irritation or actual disease? The reply to these questions varies with the case. For

mobility of the joints, from the hip downwards, must be absolutely unimpeded. A cause of want of mobility at the hip may arise in the ligaments of the joint, in the very numerous muscles that surround it, or in the neck of the thigh bone—that part between the shaft of the bone and the socket of the haunch bone, and which is at an angle with the shaft—or in the synovial membrane within the joint. The hip joint is so hidden by muscle that to estimate the nature of the impediment is made difficult. Any want of mobility at the hip reacts at the knee and ankle joints.

Sir George Murray Humphry has also shown (1888) that the widening of the hips, such as takes place in girls at puberty, of itself modifies the shape of the extreme upper end of the thigh bone (the neck just mentioned); and that this, with the characteristic shortness of the thigh bone, has an influence on the bearings of the whole limb.

The upper and outer part of the shaft of the thigh bone, which to the touch seems so immediately beneath the skin, is in reality separated from the skin by a dense and strong layer of fibrous tissue, extending from the edge of the haunch bone down the outer side of the thigh as low

as the knee. Reference to this fibrous structure has been made at page 22. Against the inner or deep surface of this layer, under healthy conditions, the bone moves with ease and freedom, for there is interposed a double layer of that fine smooth moist (synovial) membrane for preventing friction. Should there be a want of perfect ease in the movement of the bone against this membrane, such as may be caused by rheumatic disturbance, freedom of the motion of the limb must suffer.

A very remarkable defect (at the hip) in walking has been especially described and explained by Dr. Buzzard in his book on "Simulation of Hysteria by Organic Disease of the Nervous System" (1891). Dr. Buzzard has arrived at the conclusion that the compound muscle fixed to the spine and inner aspect of the haunch bone on the one hand, and on the other to the upper part of the thigh bone, being thus the main instrument for lifting the thigh towards the trunk, may be so weakened by disturbance of its nerve supply, originating in the spinal cord itself, that the movements of the limb evince imperfection, so that walking in the ordinary way upstairs, for example, becomes difficult, if not impossible. Some most instructive instances are given by

Dr. Buzzard of this disability; one of them completely illustrates my contention that awkward walking indicates mischief demanding attention and interrogation, and is curiously *à propos* as regards the significance of ungainly walking. A girl at fifteen years of age had a peculiar gait, which at seventeen years had become stiff and stilted; at twenty years, a very definite inability to lift the knee, as in going upstairs, existed—that is, the thigh could not be brought upwards towards the trunk, and the hip joint could not be usefully moved in that one direction; the muscles that had the chief share in the duty of so lifting the limb were almost powerless, while the other muscles of the limb to all appearance were well nourished and normal, so that the girl could walk and dance. The sequel to this state of affairs happily has been that, although some peculiarity of gait remains, full muscular power has been restored.

There is a very frequent defect in the movement of the limb and foot, shown by the child's foot being brought into collision with the ankle or heel of the opposite side; this may happen from the foot of the defective side being too much inverted, or too much everted; in the one case the toe, in the other the heel, comes in contact

with the ankle. The foot may be so extremely everted that the heel of the offending foot knocks against the heel of the sound one. The cause of this state of affairs is either at the hip joint or in the muscles of the leg, which rock the foot in the forward movement of taking the step, the nerve control of the muscles being disarranged, either directly by nerve disturbance or by reflex irritation.

There is a parallel condition to be met with in horses, where the hoof of one side bruises or cuts the leg of the opposite one ; it is technically called cutting, or bruising.

[I made some inquiries respecting this of Mr. Sheather, Fellow of the Royal College of Veterinary Surgeons. He was so kind as to give me the information desired. Mr. Sheather divides the defect as, 1st, occurring in young horses ; and, 2nd, in those over four years old. In the former class the causes are, he says, malformation, too rapid growth, long journeys in droves leading to a tired condition, and a general want of muscular tone ; in the latter, the same want of tone, the exacting a pace or labour beyond what the animal is fit for, want of nervous energy, and the capacity for calling into action the various muscles at the right moments. Mr. Sheather adds the remarkable ob-

servation that this is never seen except as a consequence of febrile diseases or of straining the spine. Cutting is said to be rarely permanent. Sometimes the trouble with certain horses comes on in the spring and autumn only, and then but for a few weeks.]

The knee joint, as is often too obvious, is liable to some deflection from the line best suited to transmit the weight of the body to the foot. The state called knock-knee requires particular notice. A minor degree of this deformity may arise from the hip joint, the obliquity of the thigh tending to push the lower end of the thigh bone inwardly, and thus to put not only the ligaments of the knee, but the muscles, at a disadvantage. But in the more marked degree the bones of the knee are at fault, both the lower end of the thigh bone and upper end of the larger of the leg bones (the smaller bone of the leg does not share in the joint) participating. Sir George M. Humphry brought the subject of knock-knee, and some other deformities of the knee joint, before the profession in 1889, and he showed how uneven growth of the bones at the bone-productive layer of cartilage (see page 11) gave rise to the departure from natural form; this special

communication followed several others published by Sir G. M. Humphry, at various antecedent dates, having reference to the cardinal importance of the bone-producing stratum of cartilage, that stratum between the shaft of the bone and the moulded end immediately forming the joint.[1]

It is probable that children of quite early years, by some apparently trifling accident or strain, have injury done to this very important stratum of bone-producing cartilage. Children in tumbling about run the risk of such injury [nurses, in snatching at the falling or stumbling child by the arm, often thus cause mischief in the elbow joint].

Mr. Albert Reeves has given a full account of this disordered growth ("Bodily Deformities," 1885), and he confirms the statement that the

[1] Professor Charcot first detected the relation of certain changes in the nervous system to the disordered state of the nutrition of the bones and joints, as well also as of the muscular tissue. Dr. Buzzard holds the view that there is a centre of nerve force presiding over the nutrition of the bony skeleton and the joints, and he has, following up the investigations of Charcot, elaborated this in his "Lectures on Diseases of the Nervous System," and has logically concatenated the phenomena attendant on the form of disorganization of bones and joints found in association with nerve diseases.

larger leg bone, as well as the thigh bone, is in some cases to blame, and narrates how the prejudicial condition arises in the growth of the bone or bones.

The opposite condition of knock-knee is seen in bow-leg. In both knock-knee and bow-leg the weight of the body is transmitted to the ankle joint in an unfavourable manner, which interferes with the natural movement of the foot. The leg bone, at its lower end, in knock-knee, is thrust outwards ; in bow-leg it is thrust inwards ; so that in both the side ligaments which hold the leg bones to the foot are strained.

In knock-knee, the foot during walking is most commonly turned excessively outwards, and the rolling action of the foot, instead of being towards the great toe, terminates at the middle of the inner edge of the foot ; in bow-leg, the tendency is to turn the toes inwards, and the rolling action takes place toward the outer edge of the foot and to the little toe.

At the ankle joint, the instep, and the joints of the foot, we most often find palpable and characteristic examples of defect, and to describe them it will be necessary to make reference to the structure of the ankle and foot. It must be

borne in mind that, during certain movements in walking, the whole weight of the body has to be sustained by one foot.

Suppose the weight of the body to be eight stone, that is 112 lbs., or even half that weight, the strain on the ankle joint is no trifling matter.[1]

The bones of the leg at the ankle ride on the topmost of the seven short bones of the foot. This topmost foot bone has a two-fold support; it rests behind on the largest of these seven bones, the heel bone, and is bound to it by very strong ligamentous fibres; in front, it has a projecting rounded head, which is supported by a short, horizontal, partly elastic bridge of ligament. The ankle bones, as the prominent ends of the large and small bones of the leg are commonly called, are held by ligaments to this topmost bone of the foot, and to the heel bone, variously attached.

Many and multiform ligaments connect di-

[1] As an example of weights noted of some children, taken at haphazard. Girl, aet. 9, 4 st. 5 lbs. (61 lbs.); girl, aet. 15, 8 st. 5 lbs. (117 lbs.); girl, aet. 10, 3 st. 12 lbs. (54 lbs.); boy, aet. 12, 5 st. 10 lbs. (80 lbs.); girl, aet. 5½, 3 st. (42 lbs.); girl, aet. 12, 5 st. 7 lbs. (77 lbs.). These weights include the clothing, as, of course, from the present point of view, the weight of the clothing has as much to be reckoned with as the weight of the body.

rectly all the bones of the foot, and there is, besides, a strong fan-shaped fibrous structure which extends from the under part of the heel to the front of the foot, on its way splitting up and being variously associated with the muscles and with those bones of the foot from which the toes spring, so that it forms a tie-beam to the arch of the instep, the front of the foot being thus linked with the heel. A mass of muscle occupies the hollow of the arch lying between this fan-shaped fibrous layer and the bones, and, passing forwards from the back of the sole of the foot, helps to strengthen the instep in walking and standing, in locomotion and station ; another example of the distribution of strain in the mechanism of the body.

Moreover, the normal shape of the foot, with its arches, lateral and longitudinal, is in a most essential degree maintained by a balance of muscular action, the action of the muscles of the leg, especially of those which are hidden by the calf muscles, and also by those muscles originating from the outer side of the leg.

A flattening of the instep—flat-foot—has been ascribed to simple weakness of the ligaments. Doubtless in some cases the ligaments, from the

beginning, are deficient in strength, but the ligaments under any circumstances are inadequate to preserve the arch of the foot.

The preservation of the arch of the foot is essentially dependent on the action of certain muscles, as just stated, but it is interfered with by a defect in the compound muscles of the calf of the leg fixed into the heel bone, for, when this is not of due length, a full bending forward of the leg upon the foot is not permitted, and the effort towards that movement causes the foot to get, so to speak, a list to leeward; thus an injurious strain is put upon the ligaments, and upon one ligament in particular, that horizontal bridge ligament that supports the front of the topmost bone of the instep, on which the leg bones ride. This result of contracted or short calf muscles is constantly seen in children, the subjects of a form of paralysis, to which quite young children are peculiarly liable.

Dr. J. Symington, Lecturer on Anatomy, of Edinburgh, has most minutely described the change in the foot resulting from acquired flat-foot. He adverts to the rarity of specimens in the different museums. I take this as showing how little serious attention has been given to

the subject. Dr. Symington agrees with Mr. Golding Bird that the hinder half, measuring from the centre of the arch of the foot, is longer naturally, and is made longer still by falling of the instep.[1]

It may be here mentioned that, with the leg straight, the foot should be able to be bent towards the leg, so that the foot forms with the leg a more or less acute angle. In most cases of flat-foot, or falling of the instep, it will be found that the foot can be so bent barely beyond a right angle, as the shortness of the calf muscles prevents the descent of the heel, which obviously must take place before the front of the foot can be lifted towards the leg.

Beyond the instep, abnormalities of the toes are the source of many troubles. The displacement of the great toe, with enlargement of the joint, commonly known as bunion, and a crumpling up of the smaller toes, are often the cause of lameness and of suffering. These distortions develop during the active stages of growth, and it is worthy of remark that the crumpling of the toes begins earlier than does bunion, and that there is a difference in the liability of the sexes. The

[1] "Journal of Anat. and Phys.," 1884.

cause of these distortions is not so simple as is usually supposed.

Surgical writers seem to find it impossible to get away from the very old belief that bunion and the crumpling of the toes are caused by short shoes, and they cling to that plausible but transparent fallacy; for example, one recent author lately (1891) wrote that bunion "must be regarded as a simple malposition caused by the use of boots of the wrong shape."[1] The same tale is told in most, if not in all, surgical treatises.

Now, in the first place, one may see extreme condition of bunion in people who have never worn shoes, or, at any rate, do not habitually wear them; and, in the second place, a pressure competent to dislocate the toes would be insupportable. The shoe theory offers no explanation of the hereditary nature of a considerable number of cases, nor of the fact that the displacement of the toe in bunion goes on increasing as age advances, although there may be plenty of room, and to spare, in the shoe.

[1] And a like suggestion has been made as regards retracted toes by a writer in "Pathological Society's Transactions," vol. xxxvii., 1886.

I contend that the displacement begins in a nervous and muscular fault, which continues and increases the mischief. Mr. Adams says:[1] "It is certainly not traceable to the child wearing short boots. I have frequently seen it where the greatest care has been taken that the boots worn by the child should be of full length." Although I thus traverse the statement that badly made shoes cause distortion by simple dislocative pressure, it seems to me probable that great harm may be brought about through bad shoes, by means of injury to the nerves of the foot, thus causing disturbance of the nerve supply[2] to the muscles especially belonging to the foot, of the same nature as any more obvious mechanical violence to the trunk of a nerve in the leg, an instance of which I give at page 70.

[1] Contraction of the second toe, &c., p. 124, 1892.

[2] "Scrivener's cramp" is due to some disordered condition of the nerve supply to the muscles of the hand and arm. The same trouble occurs from the same cause in violin players. In the Dresden Gallery is the celebrated picture of the Reading Magdalen, by Battoni, familiar to many by the engravings. The woman who served as model to the painter had, in a marked degree, displacement of the great toe; it is doubtful whether she ever wore tight shoes. This illustration of lateral displacement of the great toe is not the only one that may be culled by a study of the old masters.

I endeavoured[1] some time since to show that the real cause of the displacement lay in the condition of the muscles, induced by disturbance in the nerve supply; and to indicate how, in numerous instances, the spinal nerves were disarranged, and that the crumpling of the toes was of the same nature as the condition of the fingers in "la main en griffe"—that is when, in consequence of injury to the nerve supplying or animating the muscles of the hand, the fingers cannot be fully extended and assume a claw-like appearance, as was pointed out by M. Duchene de Boulogne, by whom my attention was first drawn to the question.

I must here interpolate an example of hereditary distortion of one toe, as relevant subject of the argument.

A lady had retraction (crumpling up) of the second toe, for which she had consulted me; her son, at the age of twelve years, also came under my observation on account of weakness of the ankles and shortness of the calf muscles, which prevented his taking part in the game of football, almost obligatory at the public school to which it was proposed he should be sent; at that time

[1] "Trans. of the Clinical Society of London," vol. xi.

there was no retraction of any one of the toes, but later on, when he was almost fully grown, I found he had a retracted toe corresponding to that of his mother.

The retraction of the lesser toes, so that they are drawn upwards at the middle joint, instead of lying out at full length, involves further mischief, those joints where the toes are attached to the bones of the foot being thrust downwards, and bunion in the sole of the foot is the result, as the whole weight of the body is thrown on to the tissues of the sole at these points. Where this condition of retraction exists, the movement of the forward rolling of the foot (see page 37) ends at the ball of the foot, in place of at the tips of the toes, and a jerky, saltatory, affected style is given to the step. In this way, only three-quarters of the foot is utilized.

This faulty, incomplete rolling of the foot is betrayed on inspection of the sole of the shoe, which shows itself to be unduly worn in the centre part; this condition of the sole is almost invariably found to be the indication of retracted toes in the wearer of the shoe.

But to the spine itself and to the spinal cord we have to look for the explanation of failure of

muscular energy, and of the want of orderly muscular energy.

The late Dr. Little said,[1] " A slight degree of flat-foot " (falling of the instep, failure of the arch of the foot) " is common in girls,[2] especially of the upper and middle classes." It is well known that some degree of lateral curvature is very common in the sex and in the classes specified by Dr. Little.

Sir Benjamin Brodie and others mention that falling of the instep is very often coincident with lateral curvature of the spine, but no stress has been laid by them upon the possibility of a defective or disturbed state of the nervous supply of the muscles being a factor in the production of the distortion.

There is, however, a question bearing on the relation of the lower limbs to the spine, namely, the frequent inequality in the length of the lower limbs. This inequality, as a cause of deviation of the spine, has not often been fully recognized ;

[1] " Holmes' System of Surgery.

[2] In the female the annual rate of growth after the age of fourteen is feebler ; her growth terminates about two years before that of the male ; while at the age of thirteen girls are a little taller than boys, at the period of full development women are nearly four inches shorter than men.

I must nevertheless state that Mr. Noble Smith has fairly dealt with this subject. It is true that writers on spinal curvature have mentioned imparity of the lower limbs as a cause of curvature, but from the drawings to illustrate their text it is clear that they were contemplating a much greater inequality than that one here referred to, which is of remarkable frequency.

A certain number of measurements of dry bones have been made, and, as far as the measurements of dry bones carries us, it would appear that in only ten per cent. of the skeletons measured were the bones of the lower limbs of opposite sides found to be of equal length; these measurements, which included the bones of many different races, were published by Dr. Garson in 1879.

Dr. Morton,[1] of Philadelphia, measured five hundred boys between the ages of eight and eighteen years; in less than half did he find the legs of equal length. In a large majority of the boys whose limbs were not equal, the difference was from $\frac{1}{8}$th to $\frac{2}{8}$ths of an inch, the right limb being the longer in over two-thirds of the number (Dr. Garson's measurements of seventy

[1] Dr. Thomas G. Morton on "Inequality in Length of the Lower Limbs."

skeletons show the left limb to be the longer). Dr. Morton, in 1888, wrote on this subject, and directed his attention to inequality in the length of the lower limbs as a cause of curvature of the spine. In the same year I published a paper[1] in which I described what I believed to be the consequences of the inequality in the length of the lower limbs, one of these consequences being that in the erect position, in order to bring the head in the direct line with the centre of gravity, some degree of lateral curvature of the spinal column must arise, and elevation of the shoulder on the side of the *short* leg.[2] It is impossible that the

[1] "On certain Disregarded Defects of Development chiefly in relation to the Curves (normal) of the Spine, 1888.

[2] The effect of the inequality may be illustrated by the following simple experiment:—

Rule two parallel horizontal lines six inches distant from one another on a sheet of paper, say eight inches long by six inches wide.

Take a second smaller piece of paper, six inches long by three inches broad, and cut off from each side a strip one inch wide by five inches long; this will leave the paper T shaped. When placed on the first piece of paper so that the uppermost edge of the T shall coincide with the top line, the lower edge of the foot of the T will coincide with the bottom of the two ruled lines. Now cut a wedge-shaped or triangular piece, having a base of $\frac{1}{8}$-inch from the foot of the T; this makes the vertical part of the T shorter on one side than the other.

Place the T, mutilated thus, between the two parallel

act of walking can be perfectly true with the legs of unequal length.

Dr. Morton says: "Although an inequality in the length of the lower limbs may never cause symptoms, and thus fail to be recognized by the individual, yet occasionally it happens that this defect becomes an important factor in the production of disease."

It is immaterial from the present point of view whether the right or left limb be the longer as regards the production of a lateral curve. The bending of the spine to one side or to the other, so long as the body is in the erect posture, necessitates an undue effort of the muscles of the loin and back, on

lines already drawn, so that the edge of the foot shall coincide with the bottom line. The cross-bar of the T will not be found to coincide with the upper of the parallel lines, but will be "on the slant."

Correct this "slant" by making it horizontal, adjusting it with the fingers. Two things will become apparent; the upper edge of the T will not coincide with the first of the ruled lines, but will be below it, and the side of the perpendicular part of the T which corresponds to the point of the wedge, the apex of the triangle (cut off), will bulge up.

The short side of the T will represent the short leg; the bulging of the longer side will represent the curve of the spine, which is instinctively made by the subject of the inequality to correct the disturbance of the centre of gravity, and the inconvenience, to say the least of it, of having the two eyes at different levels.

the side of the longer limb to adapt the centre of gravity, an inordinate one-sided tax on muscular energy which may react on the internal organs.[1]

This form of lateral curvature of the spine, which may almost be described as intermittent, as it belongs to the erect posture, vanishing on sitting down, appears to me to disarrange the perfect function of the spinal cord, and entails serious mischief.

Sir James Paget writes :[2] " Of the cases in which deformity of the spine is feared, on account of some more abiding unusual shape, some are associated with inequality in the length of the lower limbs. . . . Exact equality in the length of the limbs is rare, but if the inequality be not more than a quarter of an inch, it will hardly be observable at the spine. A greater inequality may so lift up the pelvis" (haunch bone) " above the longer limb that the flank must appear sunken

[1] Dr. Morton, on the authority of Mr. Hubbell, of Philadelphia, gives an illustration of the ultimate result of an apparently insignificant fault in mechanical construction : " The variation of but one-tenth of an inch in the perfect circularity in the tires of the driving-wheel of a locomotive has been known to squander energy enough, measured in the ost of extra consumption of coal, in a few years to buy a new locomotive."

[2] "Studies of Old Case Books," 1891.

in, and the lumbar" (loin) "part of the spine must be habitually, however slightly, curved."

For my own part, I venture to assert that the lateral curvation, owing to an inequality in the length of the lower limbs which is constantly overlooked, indirectly induces various kinds of ill-health, and, short of that, pains in the back and aching spine, incapacity for ordinary avocations, and quickly brought on fatigue.

Interference with the due supply of nerve influence is one of the chief causes of ungainliness of gait. There are many ways in which the muscles may be deprived of the necessary nutritional nervous stimulus. Damage to the brain disfranchises the nerve fibres proceeding from the disorganized part to the spinal cord, and the muscles suffer. There may be faults in the development of the spinal cord itself, incident to the change in the relative lengths of the spinal cord and the spinal canal in which it lies, during the period of the rapid growth of the body, or the cord may be the seat of some diseased changes.[1] There may be a condition of the nerve trunks ob-

[1] Charcot described the changes in the spinal cord causing wasting of muscle. "Pathog. Soc. Trans.," vol. xxviii.

structing the nerve current, a condition brought about by direct injury, or by inflammatory disease, mischief originating in extrinsic or intrinsic influences; that is to say, by something acting from the outside, or by a constitutional or internal disturbance, such as a severe fever. The following is an example of interruption of the nerve current by external injury to a nerve trunk. A young woman, aged twenty-one, at the time of my first seeing her, had received, seven years previously, a blow at the back of the knee joint, which bruised one of the large nerves of that region, the nerve belonging to the muscles of the outer side of the leg, the tendons of which are fixed to the foot. A good deal of pain down the nerve followed the injury, and remained a long while, as I gathered from the girl's report of herself. The result was that the muscles became impoverished and weak from the want of due nervous stimulus, and the foot acquired a tendency to turn sole inwards; further, the toes crumpled up, and there was a constantly recurring spraining of the ankle; the young woman was thus incapacitated; but, after persevering massage, the weakened muscles recovered, and she was able to walk firmly, and to earn her living as a domestic servant.

In illustration of the effects of internal mischief, I would mention the case of a man who, when young, had an attack of small-pox; an arrest of development of the upper limbs followed it, so that while he had the body of a fully grown man, his arms looked like those of a boy. The *Lancet*, August 27th, 1887, contained an article on the result of another eruptive fever, to wit, measles. The article is a long one, and gives a careful *résumé* of the opinions of several physicians, but refers especially to the researches of Pitres and Vaillard, and of Dr. Thomas Barlow who found evidence of distinct hæmorrhagic mischief in the spinal cord (bleeding amongst the fibres) in a case of measles. The writer of the *Lancet's* article goes on to say: "Although the occurrence of such marked lesion in the cord is unusual, still we must admit the possibility of a slighter vascular disturbance of the cord as a more general concomitant of severe measles." A constitutional condition of the system (gouty) will interfere with sometimes one nerve, sometimes another. A common example of nerve trouble is sciatica, causing wasting of muscle; less observable is the gouty failure of the nerve animating the greater bulk of the muscles of the hand,

making the hand appear somewhat withered, by a hollow forming between the bone that supports the thumb and the corresponding bone of the next finger, this space being occupied under healthy conditions by a bulging mass of muscle.

Another example of nerve deterioration, not the result of mechanical injury. The patient, a young lady, ten years before coming under my observation, had an undefined illness, followed by pain in the left loin. She was then seventeen years of age, and fully grown as regards height. When seen by me, walking had become painful from severe bunion and crumpling of the toes ; the left leg was considerably wasted, a condition that had been hitherto overlooked ; the foot could not be fully lifted, the shortness of the calf muscles preventing, and the thigh could not be drawn up with the same ease as that of the opposite side, as there was want of mobility of the muscles connected with the hip joint. It is probable that there had occurred, at the time of the illness, some inflammation, either of the trunks of the nerves or of their envelopes, of a rheumatic character, and had treatment at an early date been resorted to, the lameness might have been obviated.

I have already alluded to the possibility of lateral curvature of the spine being a cause of interruption to nerve stimulus. Lateral curvature is an abnormality; but the natural curves of the spine may, nevertheless, by exaggeration or by deficiency, likewise prove prejudicial. A young lady, about sixteen years of age, was brought to me by her parent, on account of a liability to twist the ankle, without sprain, as there followed no discoloration such as is seen ordinarily in rupture or tearing of a ligament when there is a real sprain. I found an excess of the forward curve in the loins, so much as to render her apparent height *less* by two inches, or thereabout, than her real height. This excessive curve interfered with the nutrition of the muscles which should sustain the foot in its proper position as regards the leg bones; consequently slight inequalities of the ground caused the foot to turn over in walking.

The fore and aft curves spoken of at page 30 (not especially human, they having their representatives in animals that go on all fours) confer an elasticity and extensibility on the spine. These curves constitute one of those provisions in the animal frame against sudden strain or tax on the strength of a part, and afford protection to the

brain and spinal cord against jar in abrupt movements. There are other examples of such provision against shock in the blood vessels as well as in the muscular system.

As these curves should be developed at maturity, it follows that a lack of curve is an imperfection, and an excess a deformity. Defective development may thus be positive or negative—may consist in the persistence of a normal but provisional condition, or the non-growth of what ought to grow. Some results of defective development are direct and mechanical, some reflex and nutritional.

A structure so exquisitely delicate and sensitive as the spinal cord, suited to rest in the canal of the backbone, having certain natural undulations, must have its function interfered with when these undulations are abnormal in a degree, especially if complicated with a morbid curve to one side or the other, a lateral curve, whether arising from some irregularity in the growth of the separate vertebræ, or from a tilting over of the haunch bone by reason of an imparity of the lower limbs. As an example of the result of deficiency of curve, I add this case. A young man applied to me on account of lameness in his feet, which caused him to suffer much pain, as his occupation

necessitated a standing posture the greater part of the day. I found that the toes were much crumpled up, that he had bunions, and that the spine in the region from the waist to the neck was unduly vertical; the normal fore and aft backward curve had not been developed. I have so often seen this undue straightness of the upper part of the spine co-existing with the distortion of the feet, as above specified, that I cannot but look upon them other than as cause and effect.

It has occurred to me to question whether what are commonly called "growing pains" are not brought about by the commencement of the development of the normal curves of the spine.

Among the causes of awkward walking from reflex disturbance of the nervous system, dental irritation may be suspected to be one. The jaws in childhood, only developed so far as to accommodate twenty teeth, afterwards have to expand and give room for thirty-two. The disturbances liable to attend the appearance of the first set of teeth and the eventual expansion of the jaw are many of them of a reflex character.

In 1877 I contributed a short paper to a medical society in corroboration of the views of the late Mr. Samuel Cartwright, who held the

opinion that certain nervous affections depended on the physiological state of the system induced by dentition, and I gave instances where disease of the eye had arisen from dental irritation. Papers by others have since been published giving illustrations of the significance of dental irritation in disorders where such irritation had not been previously looked for as a cause.

St. Vitus's dance—chorea—is a disorder attacking children most frequently just before puberty, and has been ascribed to a rheumatic state which has affected the heart. Arguing from the figures afforded by Dr. West,[1] namely, that out of 422 cases 363 occurred between the fifth and twelfth years of age; as this period coincides with the cutting of the second or permanent set of teeth, excepting the wisdom teeth, the suspicion is justifiable that dental irritation has some share in disturbing the functions of the spinal cord, of which disturbance chorea is a symptom or sign, and which will generally subside when the "second molar" teeth are cut. Dr. Landon Gray, of New York,[2] writes: "The *rôle* of articular rheumatism in the causation of chorea has been much over-estimated,

[1] "Diseases of Childhood," 5th Edition.

[2] "Treatise on Nervous Diseases," etc., p. 409.

and the idea that chorea was a rheumatic disease is entirely untenable." As another example of loss of muscular equilibrium which corresponds in point of time with the cutting of the first tooth of the permanent set, about the fifth or sixth year, is the squint that so often makes itself evident at that date, notwithstanding squint is sometimes to be observed at birth. The explanation that has been given by oculists of the squint becoming manifest at the fifth year is that certain defects of vision begin to take effect, in consequence of the child commencing at that age more closely to employ the eyes.

With regard to the lower limb muscles, the disturbance of the nervous system by dental irritation is illustrated by a case that came under my notice some years since (January, 1886). The young lady, in her ninth year, was observed by her friends to be unable to stand unless the feet were widely separated; when the feet were brought close together, she would fall forwards; the calf muscles of both legs were somewhat contracted. I imagine that the falling forward was due to an instinctive forward bending of the body to prevent falling backwards; she had a squint of the left eye, her teeth were irregular. Mr. Pillin, of

George Street, Hanover Square, treated the dental defects, and diligent massage was employed to the muscles; by the following October the squint had disappeared, and also the inability to stand with the feet together, the body weight having increased in the ten months eight and a half pounds.

A further example of awkward walking. A girl in her eleventh year, well grown—that is, she weighs 5 stones 2 lbs. = 72 lbs.—walks without putting the left heel to the ground in the ordinary step; she can stand with both feet fairly placed. There is only about a fourth of an inch difference in the circumference of the legs, the left being the smaller; there is no shortness of the calf muscles. In bringing the left foot forward in walking she does not quite clear the right ankle; this is shown by the boot over the right ankle being cut through, while the boot over the left ankle is untouched. Those teeth that are due at the tenth year show no signs, and those due at the ninth year are not all fully "cut." Dental irritation of reflex nature may here be the primary cause of the symptoms, as no condition of the muscles of the limb sufficient to account for the phenomenon is to be found.

In another direction, I have observed reflex

disturbance concomitant with the cutting of the teeth; for example, ophthalmia of different kinds in early life; and, later on, when the wisdom teeth are making their way through the gums; in young women, the constitutional health under such circumstances is often deranged, the complexion alters, the hair falls, and sometimes distressing pains across the head and in the eyes prevail when any kind of work that calls for ocular strain is attempted, so that reading or writing, for example, becomes impracticable.

Marked peculiarities in walking should draw attention to the state of the jaws as regards dentition.

It has to be stated that the hypothesis of dental irritation being a cause of nerve mischief does not find favour with some specialists; one physician (specialist) denies that there is proof of any relation between dental irritation and that serious nerve affection called infantile paralysis.

Mr. D. Corbett, of Dublin,[1] has recorded a case of dental irritation reacting on the lower limbs as well as on the eye.

[1] "British Journal of Dental Science," vol. xxiv., p. 823: "Evidence of reflex action in relation to constitutional disturbance during second dentition."

A young lady at seventeen had suffered no illness until her fifteenth year, when weakness of the lower extremities showed itself, accompanied by occasional impairment of vision. The weakness of the limbs increased, until the power of walking about unassisted was lost; every kind of treatment had failed to do good. Mr. Corbett, by almost a chance, had the opportunity of examining her mouth; he found evidence of severe pressure from the wisdom teeth against the next teeth ("the second molars"), so much as to produce displacement outward of these teeth. Mr. Corbett removed them, and within a week improvement was marked, and in three months the nervous disturbance, with the exception of the eye trouble, had vanished.

But going the other way round, both Mr. Brudenell Carter[1] and Mr. Bickerton (of Liverpool)[2] have given cases where ocular strain from defect in the eye produced symptoms like those of brain disease.

[1] "Transactions of the Clinical Society," 1874.

[2] Liverpool Medical Association, 1886.

PART IV.

CORRECTION AND PREVENTION.

The restoration of lost power, and the overcoming the resistance of contraction of single muscles or of groups of muscles, are the primary aim in the correction of defects in walking, whatever may have been in the first instance the cause of the loss of power or of the contraction. Feeding, clothing, and exercise are the general means of keeping up a good standard of health. Gymnastics, massage, and galvanism are the special and direct agents for correcting derangement. To meet exigencies, gymnastics must be systematized and modified.

Under the ordinary circumstances of good health, exercises should be directed to the *equal* development of all the muscular parts of the body, and be kept well within the compass of the vital capacity of the individual. Exercises in excess cause an undue strain to be put on the heart and lungs; but exercises duly regulated give increase of strength, suppleness, and better carriage, and, by equalizing the distribution of the mus-

cular and nerve force, also promote a uniform healthy condition of all the functions of the body.

Special gymnastic exercise and treatment can be applied to single muscles if debilitated with analogous effect. It has first to be determined what muscles are at fault, and it must be remembered that, although the cause of such muscles being unequal to their task may be no longer operative, there may have accrued prejudicial conditions, for, whenever a muscle has been thrown out of work, it immediately tends to shorten or shrink: this is a very important fact, and is much overlooked.

Ling's system, known as the Swedish system of gymnastics, is from this point of view the best. The exercise of separate muscles, or of subdivisions of groups of muscles, is a leading feature in the application of the system. The causing separate enfeebled muscles to work independently is like calling on a deficient member of a chorus or orchestra to attend extra rehearsals.

General gymnastic exercises of a simple character should form a part of the daily education of every growing child, as a matter of hygiene.

There are several general gymnastic exercises that may be carried out at home, when resort to

a gymnasium is not practicable, it being premised that no exercise should be continued to fatigue.

1. *Breathing Exercise.*—(*a*) Let the arms be fully extended at right angles to the trunk, the shoulder blades being drawn well back; then let deep full inspiration be slowly made. (*b*) Let the thus inspired air be forced out by the muscles of the abdomen assisting the ordinary chest muscles of expiration. The rebound of the elasticity of the ribs and their cartilages will be very observable when these have finished contracting.

2. *Spine Exercise.*—(*a*) Raise the arms vertically above the head, keeping the lower limbs straight; then bend gradually forward, until the fingers can touch the front of the foot. (*b*) Resuming the upright position, bend the spine as much as possible in the opposite direction. In these two exercises the abdominal and back muscles are strongly, but steadily, called into play. (*c*) Bend the spine, i.e. the trunk, alternately to the right and to the left.

3. *Limb Exercise.*—(*a*) Standing by the side of an ordinary chair, slowly raise one foot so as to place it on the seat of the chair. (*b*) Carrying a light weight on the head, walk slowly upstairs, one step at a time. (*c*) Walk slowly upstairs,

two steps at a time. (*d*) Walk slowly downstairs, one step at a time.

4. (*a*) Standing half the length of the foot from the wall, bend the knees forward so that they shall touch the wall; (*b*) repeat this bending to the wall with one leg only, stretching the other as far as possible backwards, with the knee straight.

5. With the feet together, stand on tip-toe.

6. With the feet together, raise the front of the feet so that the weight of the body shall rest on the heels.

7. Where a staircase with a handrail on each side is available, ascend the stairs with the help of the arms, the hands taking hold of the rails.

On no account should a child be allowed to jump down from two or three stairs, or from any height; irreparable injury to the bone-developing cartilage may result. No educational exercise is involved in such exploits.

In the attempts to correct deviations of the spine, or to rectify some of the secondary weaknesses, especially when such are due to an inequality in the length of the lower limbs, the great advantage of systematic gymnastics based upon anatomical and physiological facts is that the weaker muscles, those most needing help, get bestowed upon them

the greatest share of the treatment; whereas, if a knowledge of these facts be wanting, the individual, the subject of the lameness, in endeavouring to correct the faults, would most probably make the efforts in the wrong direction. Therefore, where systematic exercises are not obtainable, simple uncomplicated symmetrical exercises only are safe.

Mr. John Holm, my friend and former pupil, one of the earliest surgical exponents of Ling's system (the Swedish) in this country, has been so kind as to compile a list of such exercises as can be put in force at home. Mr. Holm's directions go further and teach more technically than the very elementary suggestions I have given. It may not be out of place to say that the aim of Ling's system, the working and effects of which I have watched during many years, is not confined simply to guiding harmonious bodily development in the strong and healthy, but extends itself, by being delicately modified and graduated, to the restoration of the enfeebled; while its completeness enables the exercises to be localized so as to encourage the return of strength and function to those parts betraying weakness and failure.

Mr. Holm's suggestions and instructions are as follows :—

1. The child should stand close to, and facing a wall or door, his feet being at an angle of 45°, the toes touching the wall. The hands should be firmly placed on the hips, the thumbs being behind and the wrists bent well down. The knees should be kept perfectly straight, the head maintained in the upright position with the chin well down, the whole body facing equally forward. The abdomen should be kept in close contact with the wall. The above positions being maintained throughout the "movement," the body should be then bent slowly backwards as far as possible without losing balance, returning to the original position.

The movement should be repeated from three to six times.

2. The child should stand on the edge of a firm table, the feet being separated to the width of the shoulders and turned outwards to an angle of 45°. The arms should be then raised, the elbows being kept straight, to a vertical position in line with the ears, and parallel to each other. The trunk should be then bent, carrying the head and arms equally and slowly forwards and down-

wards; slightly bending the knees, the edge of the table should be grasped with the fingers. The knees should be then slowly stretched until a strong tension be felt behind them, and extending along the spine. Repeat three to nine times.

3. The child lies face downwards on a table, the hands being fixed on the hips; each leg should be then alternately raised, keeping it perfectly straight, and taking care not to turn (twist) it during the movement. Repeat from three to six times.

4. A. The child lies on his back on a table, being especially careful that the shoulders, hips, knees, and feet face equally upwards, the arms being stretched upwards in front, the elbows, wrists, and fingers being perfectly straight, the palms facing and the arms parallel to each other; both arms should be then slowly lowered in the vertical plane until they reach the horizontal position, making at the same time an effort to draw the shoulder blades together. Repeat six times.

4. B. Starting from the latter position, the child should draw the elbows slowly to the sides, at the same time bending the elbows until the

fingers touch the shoulders; with great concentration, but without violence. Simultaneously the shoulder blades should be drawn together. Repeat three to six times.

5. The child should either sit on the front portion of a chair or stand with the feet placed as in No. 2. The hands being firmly fixed on the hips, then, slowly and steadily, the trunk should be turned as far as it will go without bending, first to the left, then to the right, being careful that the elbows maintain their relative position, following the movement of the body. Repeat four to six times.

6. The child, standing, is to advance one foot twelve inches forward, then, raising both arms to the horizontal position, the palms facing the floor, should slowly rotate the arms, describing a circle with the fingers. Having performed the rotation from four to nine times, his *deep* respirations should be commenced when the arms are in the most forward and downward position, "circling" them gradually upwards and backwards as the inspiration is made; backwards, downwards, and forwards as the expiration is made. Four to six respirations. The feet should then be changed, and the movement repeated as before.

The inspirations should be made slowly, deeply, and steadily, all spasmodic effort being avoided, but the respiration in each case being pushed to the extreme.

7. The child should lie face downwards on the floor or on a table in a perfectly straight position, with the hand fixed on hips. The feet must be held firmly down by another person. The child then raises the body slowly upwards, at the same time throwing the chest well out and drawing the shoulder blades—but not the elbows—well back, so that they approximate to each other. Then the trunk is to be slowly lowered to the starting position. Repeat two to six times.

8. The child should lie flat on the back with the feet firmly fixed, as in the last movement, with hands on hips. Then the body should be slowly raised, the knees being kept straight and brought forwards as far as possible; both arms should be then stretched forwards until the toes can be grasped; the body should now be brought to the vertical position; the hands having been replaced on hips, the body should be slowly lowered to the horizontal position. Repeat two to six times.

N.B.—When accuracy in performing the move-

ment is attained, its action can be increased by performing it (*a*) with the hands on the top of the head, the fingers being interlaced, and (*b*) the arms being stretched parallel to each other at the side of the head, level with the ears.

9. The child should stand perfectly erect, with feet closed and the arms stretched perpendicularly on each side of the body. The body should be then slowly bent as far as it will go alternately to the right and to the left, taking great care not to permit of any " twist " occurring in the spine. The chest should be kept well expanded, and the hands should slide along the outer surface of the thighs.

10. The child should stand perfectly erect, with the heels and back in contact with a door or wall. The hands should be fixed upon the hips, and deep and prolonged inspirations and expirations made, as in " No. 6."

Of massage and galvanism, it may be sufficient to say that these have somewhat similar ultimate results in promoting the nutrition of the muscular fibres. Massage is the simpler agent, and perhaps in some cases the more effective. Galvanism distinctly requires skilled application, and may, unless skill be employed, do more harm than good ; never-

theless, intelligent and persevering galvanization will sometimes give satisfactory results, even when administered only by a trustworthy nurse, who has been once instructed what is required to be done in the case. Massage must be firm and pointed, so as to be directly expended on the weakened muscles.

FEEDING.

The method of feeding children is a subject of paramount importance, the growth and solidification of the bones being dependent thereon. The change from soft cartilage to hard bone requires special food. That disorder of the skeleton called rickets, due to a want of equilibrium in the proportions of the earthy and animal constituents of bone, in most cases arises from the child being starved of some of the essential elements of food. Where a child is kept at the breast for too long a period, or, as too often happens, when the mother's milk is poor in quality, or where a wet nurse has a second child to feed, or where her constitutional condition is such as to unfit her for her duties, by causing her milk to be scanty and abnormal in the way of not containing the full amount of indispensable materials, the nursling's bones remain

soft and the ends of the long bones become distorted.

A parallel defective quality of the food later on has the same injurious consequences, and tends to produce such deformities as bow-leg and knock-knee, rickety deformities.[1]

A mother's milk may even contain something directly deleterious. As an instance, a woman brought her infant to me, covered with an eruption of pustules. The eruption appeared almost immediately on putting the child to the breast after she had undergone intense mental excitement, due to some domestic annoyance; the milk, altered by the nerve storm, had poisoned the child. Similar cases have been recorded by more than one writer.

Dr. Clement Dukes writes:[2] "With the exception of the first year of infancy—which is so largely a woman's question, and which is so

[1] To give an illustration from the mineral kingdom, that of the noxious effect, in the opposite direction, of the presence of a minute quantity of one substance in damaging the valuable characteristic of an almost comparatively unlimited quantity of another substance: in the manufacture of iron, if there be phosphorus in the coal used for smelting the ore, the metal manufactured is found to be dangerously brittle.

[2] "Essentials of School Diet."

grievously neglected—the food furnished during the period of youth is the most important of all; but it is too often little regarded, to the serious detriment of the young."

It is a physiological mistake to compel children to eat food for which they evince a repugnance. There is a great difference between pampering a child's appetite and giving food that is liked, provided it be wholesome.

A child has more chance of being underfed than overfed; perhaps not as regards quantity, but quality. Thus, to give a food not in a form favourable to digestion, or that does not include all the necessary elements for building up the frame, is spoiling the growth. A common example of an improper form of food are those polyhedrons of potato which children are so often allowed to swallow. But, overfeeding is practically starving, as digestion, the cardinal point of the conversion of food into living structure, is hindered or prevented by putting too great a load into the stomach.

Dr. Cheadle,[1] dealing with the nursery epoch of feeding, and Dr. Clement Dukes[2] with the

[1] "Diseases which Arise from Faults of Feeding in Early Life."

[2] "Essentials of School Diet."

school and playground epoch, have elaborated the study of this question.

To ensure digestion the growing child must have enough food, and of the right sort. It must be borne in mind that for the perfection of digestion a free admixture of saliva with the food is essential, and, for this, there must be an abundant supply of that secretion.

The salivary secretion, while subsidiary to the gastric juice, has nevertheless some special qualities. The quantity of the daily requirement of saliva is much larger than would be imagined; that the daily demand is from one to two pints would scarcely be guessed.

The salivary glands, which afford the supply, are numerous. The cavity of the mouth is set round with these glands, either in the form of considerable masses or of small bodies about the size of a split pea. The larger ones pour their product into the mouth at the middle of the cheek and under the tongue by distinct conduits; the small glands line the inside of the lips, and open at many points upon the smooth mucous membrane, beneath which they lie concealed.

The full functional activity of these glands depends upon the stimulation of the nerves of

the mouth, and is the counterpart of the variable activity of the tear (or lachrymal) gland. This gland, as we all painfully have learnt, may be acted on directly and indirectly; thus, the tears will flow—will be secreted—in excess of what the tear ducts can carry off, and will roll down the cheeks, from mental emotion, or from irritating vapours, or other like external impressions: at a visit to a peasant's cabin on the moorside, one's eyes may moisten at the sight of some abiding domestic misery, or—from the pungency of the reek of the peat fire. Under ordinary conditions, the tear gland secretes only enough to keep moist the membrane immediately covering the exposed part of the eyeball, and, under the same conditions, the salivary glands secrete sufficient only to keep moist the inside of the cheeks and tongue, otherwise the result would be very inconvenient. Mental emotion will parch the mouth from suspension of the function of the salivary glands; on the other hand, these glands will pour out secretion on the anticipation simply of agreeable flavours.

The salivary glands are able to start from a state of almost quiescence to one of intense activity; this marvellous change in functional condition depending on direct impressions made

on the nerves of the tongue, palate, and throat, aided by the sense of smell.

It would be too much to attempt a description of these nerves, beyond saying that they constitute a network of great extent and complex structure, having intimate connections with other nerves; and that the gustatory, or special nerve of taste, is the dominant one of this network, and has allies which take part in conveying impressions to the saliva-secreting apparatus. Not only is saliva necessary for perfect digestion, but for rendering deglutition, or the act of swallowing, possible.

Food may be, in itself, of such a nature as to supply the stimulus; but food insipid, or even of monotonous flavour, makes necessary a condiment to keep the salivary glands active.

Led by instinct, Man has discovered substances called condiments, which are capable of gratifying a craving, the nature of which he is ignorant; but the purpose of such desire in relation to digestion lies in the fact that it brings about a rush of saliva. Dr. Burney Yeo says in his notice of Sir Wm. Roberts's book on Food: "Man is a very complex feeder; he has departed, in the course of his civilization, very widely from the monotonous uniformity of diet observed in animals

in the wild state. Not only does he differ from other animals in cooking his food, but he adds to his food a greater or less number of condiments for the purpose of increasing its flavour and attractiveness."[1] The universal condiment is salt, the condiment *par excellence.* Bread and salt is a *menu* of great antiquity and of wide reputation: bread without the salt would stick in the throat; salt without the bread would not be acceptable.[2]

Salt has the advantage of giving something that the blood requires, and stands in this respect as a condiment unique; but certain other substances, pungent to the taste, which do not form an integral or essential part of food, take rank as condiments; some, by their odour appealing to the olfactory nerve, help to accentuate the power of palate nerves; even warmth may be classed as a palate stimulant. Alcohol is, in some measure, a condiment of the odoriferous order. The question whether growing children require anything in the shape of alcohol can be safely answered by the direct negative, always assuming that the child is healthy. Dr. Dukes writes in his valuable

[1] Nineteenth Century Magazine, February, 1886.

[2] Roasting meat and toasting bread is the burning of a part to make the remainder more highly flavoured.

book:[1] "Very strongly indeed do I hold that no alcohol should be given to the young, in any form or at any time, except as a remedy for sickness.

In forming an opinion, speaking generally, of the value of alcohol as an article of diet, or of its permissibility as an article of diet for grown-up people, its property as a condiment must be taken into account, and deserves to be carefully estimated, notwithstanding that it is a two-edged weapon.

"Man, like other animals, is so much the creature of his food; his physical perfection, his intellectual activity are so dependent on the food he receives and the uses he is able to make of it in the processes of digestion and assimilation, that all the details of feeding must be of the greatest interest. The diet that gives the best feeding is a varied one. During active growth the child requires an amount of food much greater in proportion to its size than the adult does for merely sustaining health, to ensure ultimately full development; this estimate is, of course, irrespective of work and labour done, every movement involving a waste or cost of tissue. The variety of the food must not only supply all the elements required for building up the body, but afford

[1] Op. cit., p. 99.

provision to meet the demands of the warmth-producing processes of the organism. The bones require lime, and, with the muscular and nervous systems, flesh-meat or vegetable equivalent. Fatty, starchy, and other substances having an analogous chemical composition, yield heat, or rather act as fuel."

To again quote Dr. Dukes: "I am not prepared to say that plenty of food during youth will add a cubit to the ultimate stature, though respecting it there can be little doubt; but it is absolutely certain that a deficiency of food during this period of life will take a cubit off the stature;" and he cites in support of his statement the investigations of Mr. C. Roberts,[1] showing the different height and weight and increase between the ages of 10 and 30 years in artisan class town population and the better fed and cared-for classes, a comparison which proves much in favour of the last named. For example, taking the three ages 12, 14, 16 years, the comparative weights are found, 52·99 against 56·97, 57·76 against 61·11, 62·93 against 66·40 respectively. To put it in another form, taking the ages of 12, 14, and 16 years, the heights collectively were as 173·68 to 184·48.

[1] Anthropometry, op. cit., p. 2.

CLOTHING.

The clothing must be flexible and unirritating. Irritation of the skin by any part of the clothing is liable to originate reflex movements which may grow into a habit. The weight, whatever may be the amount of it, with boys, may be safely put on the shoulders; no belts round the waist should be allowed. With girls, no more than a very small share should be placed on the shoulders, for this reason: there is a difference in the length of the collar bone in the male and female, as already mentioned; in the male, weight put on the extremity of the collar bone rather helps than hinders respiration; on the contrary, with the female, weight on the shoulder tends to compress the upper ribs and impede the inspiratory effort. The length and shape of the collar bone alters the brunt of strain. It is to be borne in

mind that these remarks do not apply to children of very tender years.

But the most important part of the dress, in respect of walking, is the shoe or boot. For the safety of the foot, it is necessary that the heel of the wearer should be permitted to remain perfectly steady in the back of the shoe. When this condition is not observed, the broader part of the foot at every step slides or is driven into the narrower part of the shoe, and friction is the consequence. The steady maintaining of the foot in its proper position in the ordinary shoe depends on the accurate "fit" of the instep; defective adaptation of this part of the shoe very frequently causes the wearer to what is called "step over," the fact being that it is the shoe that "steps" under, i.e. to one side. The hinder part of the foot is so much more massive than the front part, that the position of the heel and instep regulates or determines the position of the rest of the foot.

It may at first sight appear that any addition to the sole of the boot at the back part, in the shape of a heel, would help to thrust the foot forwards, by placing the sole of the boot on an inclined plane; but an explanation of the use of a

heel to a shoe may be that a lift or inclination of the heel of the wearer in a slight degree is given, and affords a start in the act of throwing the weight of the body on to the foot in advance, in preparation for taking a fresh step, helping the leverage by the foot: otherwise a heel of any height would be disadvantageous. This explanation, if valid, applies only to walking on the level, as in ascending an incline the heel does not touch the ground.

In measuring the foot for its covering, the fashion shoemakers have of tracing an outline of the foot on paper placed beneath it, furnishes that which only serves to mislead them. The outline of the foot gives no indication of the direction of the force of the tread. It thus happens that the hinder half of the shoe is built with a direction outwards, and the outer side of the foot is thus forced against the outer side of the shoe, and the inner side of the heel of the wearer against the inner side of the back of the shoe, instead of the foot being held in the proper line, namely, from the centre of the heel to the centre of the great toe. Treading over is, therefore, more often the shoemaker's fault than the wearer's; of course, assuming that the foot is not in any way deformed or distorted.

CONCLUSION.

At various dates during the past several years I have laid before one or other of the medical societies details of cases which bear upon the immediate subject of this essay. Long continued observation has confirmed me in the opinions I have expressed as to the causes of awkward walking.

It is well worth while to study the causes of ungainly gait, since a temporary functional irregularity may be prevented from growing into a highly disadvantageous habit. Further, as Mr. Francis Galton has insisted, one of the most important duties of man at the present stage of his development is to regulate the progress of the evolution of his race; therefore the study of, and inquiry into defective action of the lower limbs may be considered a part of the fringe of the great problem of the improvement of the physique

of the people: we have to search for the conditions that help to induce degenerate peculiarities of gait.

Dr. Hambleton said:[1] "Great demonstrations are constantly taking place before our eyes of the relationship between condition and types in those trades and occupations that are carried on around us," and he contends that "the type of man after birth is solely produced by the condition to which he is subject."

Early vigilance is required in the supervision of the growth of children, almost from the moment the child's first attempts to walk are being made. A rickety deformity of the bones is easily to be detected, and should at once be earnestly treated. My conviction is that the defect of development due to rickets has a very large share in the physical deterioration of the urban, especially metropolitan, population. But that misshapen limbs and feet are to be observed with extreme frequency, and not only in the least-well-off classes, due to malnutrition, must be obvious to anyone having the simplest knowledge of anatomical facts. We may safely assume that no

[1] Paper read at a meeting of the British Association for the Advancement of Science, 1887.

one would question the wisdom of Mr. Francis Galton's view of our duties in respect of promoting the just development of the race. In order to discharge those duties, there must be special as well as general knowledge.

The study of anatomy will give the special knowledge, and at the same time will enlarge the perception of wonders of entrancing interest.

It would be well if some of those who crowd the picture galleries would spend part of their leisure time in the galleries of natural history, in studying the works of nature, works which, in place of criticism, can only evoke an infinitely reverent appreciation.

THE END.

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